LIMITED ASSET MARKET PARTICIPATION, AGGREGATE DEMAND AND FED'S 'GOOD' POLICY DURING THE GREAT INFLATION.[+¤]

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Abstract. This paper argues that limited asset market participation before 1980 in the US (and the change thereof) is crucial in explaining macroeconomic performance and monetary policy conduct. Our model predicts that when participation rates change from low to high the slope of the IS curve changes from positive ('non-Keynesian') to negative (standard). We provide empirical evidence for such a change in the US around 1980. In the non-Keynesian case, a passive monetary policy rule ensures equilibrium determinacy and maximizes welfare. Hence, Fed policy was closer to optimal than conventional wisdom dictates; policy may have changed endogenously from passive to active due to the change in asset market participation. Given the structure, fundamental shocks are enough to generate most features of the Great In‡ation despite 'good' policy. (JEL E31; E32, E44; E58; E65; N12; N22; N42.)

"The seventies were indeed special." Alan Blinder [1982]

It is widely documented that during the late 1960s and throughout the 1970s, in‡ation was high and volatile, and a few recessions hit the U.S. economy. Most of the theories put forward to explain this historical record rely on 'mistakes' of

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the Fed (whether intentional or unintentional)[1,2]. However, most of these theories have di¢culties explaining why this record has changed since the early 1980s. At a deeper level, theories relying upon a change in Fed's behavior to explain the change in macroeconomic performance fail to explain why Fed behavior itself has changed.

We outline a framework that can help explain the Great In‡ation without relying on policy mistakes, while at the same time explaining why both macro performance and Fed behavior have changed. The central ingredient in our analysis is the dramatic change in …nancial markets that took place around 1980, leading to more widespread participation to asset markets. We put together institutional evidence from a variety of sources showing that …nancial constraints were especially binding in the 1970s and that deregulation and …nancial innovation led to more widespread participation since the early 1980s. We present a standard business cycle model with limited asset market participation that predicts that, at high levels of non-participation, aggregate demand is positively related to real interest rates (contrary to conventional wisdom). We provide new empirical evidence (based on estimation of an aggregate Euler equation) that the sensitivity of aggregate demand to real interest rates changed sign from positive during the pre-Volcker period to negative (as predicted by standard theory) thereafter. We show that in our theoretical model, this …nding implies that Fed policy in the pre-1980 years was consistent with both equilibrium determinacy and welfare maximization. Furthermore, we argue that the change in the policy rule from passive pre-1980 to active post-1980 could have been an endogenous response to the change in market participation, required by optimal policy. The 'Great In‡ation' can result despite good (or even optimal) policy, and due to fundamental shocks only. We assess our model quantitatively and …nd that its predictions are in line with stylized facts and existing empirical evidence.

Our approach is most related to the large literature investigating the link between monetary policy and macroeconomic performance, with a particular focus on the 'Great In‡ation' and US monetary policy in the 1970s; some recent prominent contributions in this vein include Clarida, Galí and Gertler [2000], Taylor [1999], Lubik and Schorfheide [2004] and Ireland [2004]. These studies estimate policy

[1]Some theories rely on 'bad luck', taken to come from either from: (i) larger shocks that generated greater overall variability and a more di¢cult policy environment (Blinder [1982], Sargent [2002], etc.); or (ii) 'honest mistake': the Fed was overestimating the natural rate throughout the 1970s (Orphanides [2002], Collard and Dellas [2003]). However, this theory does not explain why the good performance in the 1950s and …rst half of 1960s, nor why policy response changed in 1980. Others blame policymakers directly: Ireland [1999] emphasizes the in‡ation bias but recognizes that this only implies a long-run tendency to in‡ate and says nothing about short-term ‡uctuations. DeLong [1997] and Romer and Romer [2002] argue that the Fed were too averse towards recessions because of the Great Depression leaving its mark - it is hard to explain why the US did not have high in‡ation earlier, if so. Chari, Christiano and Kehoe [1999] emphasize 'expectations traps': in‡ationary policy, they argue, was pursued because it is a self-ful…lling equilibrium feature of discretionary policy.

[2]Many have blaimed the Federal Reserve (and in particular its Chairman during the 1970s, Arthur Burns) for this poor performance. But as documented thoroughly in Hetzel [1998] and Mayer [1999], Arthur Burns was as opposed to in‡ation as any other Fed chairmen. Moreover, Arthur Burns was, to the judgement of many, a great economist with a deep understanding of business cycles; if professional recognition is any measure of that, it is worth mentioning that A. Burns was head of the NBER since the 1940s, president of the American Economics Association, and head of the Council of Economic Advisors under two administrations.

rules relating the policy instrument (a short term nominal interest rate) to macroeconomic variables such as expected in‡ation and output gap. All the cited papers identi…ed a change in monetary policymaking with the coming to o¢ce of Paul Volcker as a chairman of the Fed in the United States. Speci…cally, monetary policy has been accommodative ('passive') in the pre-Volcker years, increasing nominal interest rates less than one-to-one when expected in‡ation increased. In contrast, Fed policy was more restrictive ('active') during the Volcker and Greenspan tenures. Since macroeconomic performance also changed[3], explaining the latter by the former (policy change) became the norm in the profession. The above-mentioned studies argue that policy before Volcker was 'badly' conducted along one or several dimensions, which led to worse macroeconomic performance as compared to the Volcker-Greenspan era. To make this point, estimated policy rules are embedded into calibrated general equilibrium models (or are estimated as part of these models, in the last two papers) to study the dynamics and variability of macroeconomic variables. These theoretical predictions are then compared with stylized facts. Clarida, Galí and Gertler (hereinafter CGG) [2000] were the …rst to argue that the passive policy rule in the pre-Volcker sample led to equilibrium indeterminacy and left room for sunspot ‡uctuations which instead led to a higher level and variability of in‡ation, and overall macroeconomic instability. However, this approach has four obvious di¢culties in explaining the Great In‡ation: (i) sunspot shocks increase both in‡ation and output (and the output gap), something not seen in the data; (ii) in the theoretical model, the e¤ects of fundamental shocks cannot be studied when equilibrium is indeterminate; (iii) the dynamics of the whole economy are entirely dependent upon the stochastic properties, the location and the origin of the sunspot shock, all of which impossible to quantify in practice; (iv) it is not clear why the Fed would have followed a policy that was so clearly suboptimal, given the model?[4]

In relation to this literature, our story unfolds as follows. The 1970s were a period of especially high …nancial market regulation, which discouraged saving and participation in asset markets. This situation triggered two responses around 1980: one from the legislators (the Depository Institutions Deregulation and Monetary Control Act - DIMCDA for short) and one from the …nancial markets themselves (…nancial innovation). We investigate whether this dramatic change could have played a role in explaining the changes in both macroeconomic performance and the way monetary policy was conducted. To pursue this exercise, we augment a standard 'new synthesis' model -widely employed in the related literature- with limited asset markets participation (hereinafter LAMP): some agents cannot trade in any asset markets, as in e.g. Alvarez, Lucas and Weber [2001], and hence do not smooth consumption as in Mankiw [2000] and Galí, Lopez-Salido and Valles [2003b]. The di¤erences between our framework and these models have to do with assumptions and purpose and are discussed in more detail in the following section.

First, we show that for low enough participation rates, the sensitivity of aggregate demand to interest rates is positive (as opposed to negative in the standard case, or for high enough participation rates). We present evidence (from estimation

[3] See DeLong [1997] for a historical account of the 'Great In‡ation'.

[4] Christiano and Gust [1999] address point (i) and show that in a limited participation model a sunspot shock to in‡ationary expectations can decrease output. But the other problems still remain.

of Euler Equations for output on US data) that indeed the elasticity of aggregate demand to real interest rates changed sign from positive in the pre-Volcker sample to negative thereafter. Secondly, we …nd that a passive policy rule is not only consistent with but also generically necessary for equilibrium uniqueness and ruling out sunspot ‡uctuations[5]. Moreover, we show that a passive interest rate rule is also the outcome of optimal monetary policy, in the sense of maximizing welfare (and minimizing in‡ation and output gap variability). A change in asset market participation that generates a change in the sign of the IS curve's slope implies that the policy rule optimally switches from passive to active. These …ndings imply that monetary policy in the 1970s was 'better' than conventional wisdom dictates. They hint to an explanation for the Great In‡ation based on structure and shocks: the structure of the economy made it such that despite a policy consistent with equilibrium determinacy and welfare maximization and not subject to systematic biases, greater macroeconomic volatility occurred due to fundamental shocks.

To verify this conjecture quantitatively, we study the dynamic response of the model economy to fundamental shocks (something impossible to do in a model with full participation when monetary policy is passive, due to equilibrium indeterminacy). First, we show that cost-push shocks can lead to higher and more volatile in‡ation and to recessions in the model parameterized for the pre-Volcker period (with low participation and passive monetary policy) than in the Volcker-Greenspan economy (with high participation and active policy). While in‡ation can be caused by a variety of shocks, we …rst focus on cost-push shocks since they also cause output to fall below the natural rate, which is a feature of the period under consideration. This explanation for the Great In‡ation squares with the view expressed by Burns and other Fed economists (see Hetzel [1998] and Mayer [1999] for reviews), as well as many academics (e.g. Blinder [1982]) at the time. While other shocks undoubtedly contribute to macroeconomic variability, Ireland [2004] …nds a larger role of cost push shock in the pre-1980 period by performing variance decompositions in an estimated DSGE model (similar results are found by Lubik and Schorfheide [2004]). We also show that the e¤ects of shocks to technology growth are qualitatively similar to those estimated by Galí, Lopez-Salido and Valles (henceforth GLV) for the pre-Volcker period [2003a]. As a …nal check, we show that systematic over-estimation of the natural interest rate (or of technology growth) could have created in‡ation in the pre-Volcker economy, as argued for example by Orphanides [2002].

To summarize, our theory is consistent with a number of stylized facts for the 1970s reviewed above (some uncontroversial, some less so), among which: (i) high and persistent in‡ation, coupled with recessions; (ii) high volatility of in‡ation and interest rates compared to the post-1980 period; (iii) a change in the policy rule around 1980; (iv) a prominent role for cost-push shocks in driving ‡uctuations; (v) non-standard e¤ects of technology shocks in the pre-1980 sample; (vi) higher in‡ation caused by policymakers' misperceptions about natural rate or technology growth. Moreover, our framework is consistent with the view that during the Great In‡ation 'the public has built up some sort of antibodies that resist[ed] the impact of

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[5]Galí, Lopez-Salido and Valles [2003b] …rst studied determinacy properties of interest rate rules in a related model (in which some of the agents do not hold capital). Their analysis is numerical, and they do note that determinacy may require violating the Taylor principle for forward-looking rules only.

higher interest rates' (Fed Chairman Miller cited by Nelson [2004]). More generally, our view that the sensitivity of aggregate demand to real interest rates changed sign can explain why interest rate increases did not work to restrain aggregate demand in the 70s, whereas they did from the 80s onwards.

The plan of our paper is as follows. In Section 2 we outline the theoretical framework consisting of a standard 'new synthesis' model augmented for limited asset market participation and derive analitically its main theoretical implications. In Section 3 we present the institutional evidence on the change in asset market participation, and some empirical evidence that the elasticity of aggregate demand to interest rates changed sign in the United States - with both changes taking place around the time of Paul Volcker's appointment as Fed Chairman. In Section 4 present theoretical responses to and second moments of a parameterized (to U.S. data) model economy to cost-push and technology shocks, incorporating the structural change mentioned above, and show that they match stylized facts and some empirical evidence. Section V contains concluding remarks.

1. Institutional evidence for the change in asset markets participation

In this section we put together some background institutional evidence suggesting that the U.S. economy in the mid1960's and 1970s was characterized by lower asset market participation as compared to the post-1980 period. This further motivates our paper's exercise.

The change in asset markets participation is problematic to pin down: there is to our knowledge no empirical study documenting such a change, let alone that data availability problems abound. Consumer Expenditure Survey data on asset holdings starts only in 1984, while the Survey of Consumer Finances over-samples high-wealth households (making it not appropriate for our exercise for obvious reasons). The Panel Study of Income Dynamics (PSID) contains wealth data with a …ve-year frequency only starting in 1984. Some wealth information is contained in the family …les previous to 1984.

However, there is institutional information to support our view that …nancial markets changed fundamentally in the early 1980s, leading to more widespread asset holding. Mishkin [1991] and references quoted therein provide a comprehensive review of …nancial market developments in this period. For a variety of reasons having to do with excessive regulation, in the '70s asset holding was limited and most assets held by small savers were not making interest linked to market interest rates. In a nutshell, two restrictions were prevalent (i) limits on interest paid by commercial banks to allow S&L to pay slightly more interest (Regulation Q), and no interest was being paid on checking accounts; (ii) discouragement of other …nancial market instruments - in 1970 Treasury was convinced to raise minimum denomination on T-bills to 10.000 USD, and bank holding companies and corporations not to issue small-denominated debt. Hence, small savers were not making the market interest rate, which was well recognized at least by Congress (and was to trigger a legislative response).

This situation changed in 1980, due both to legislators' response via deregulation and to markets' response via …nancial innovation, causes which are sometimes hard to disentangle. On the latter point, Wenninger [1984] and Silber [1983] list literally hundreds of instruments created by …nancial innovation, most of them gaining wide usage in the post-1980 period[6]. On the former point, 1980 saw the adoption of the Depository Institutions Deregulation and Monetary Control Act (DIDMCA)[7]. Its basic purpose is stated clearly in the …rst paragraph: "(a) The Congress hereby …nds that: (i) limitations on the interest rates which are payable on deposits and accounts discourage persons from saving money, create inequities for depositors, impede the ability of depository institutions to compete for funds, and have not achieved their purpose of providing an even ‡ow of funds for home mortgage lending; and (ii) all depositors, and particularly those with modest savings, are entitled to receive a market rate of return on their savings as soon as it is economically feasible for depository institutions to pay such rate." Among the most important provisions, the DIDMCA introduced a phaseout of Regulation Q, let Savings&Loans Institutions make other types of loans and engage in other activities, approved many of the new instruments mentioned above nationwide, eliminated usury ceilings on mortgage loans and some business loans and provided uniform access to Fed reserve facilities for all depository institutions.

To give just an example (see Mishkin [1991]) of the magnitude of the change in …nancial markets: total assets of Money Market mutual funds increased from 4 billion in 1978 to 230 billion in 1982, and NOW accounts increased from 27 to 101 billion from 1980 to 1982. Moreover, the early 1980s saw the advent of Individual Retirement Accounts (IRAs), an important new saving vehicle. The introduction and spreading of new …nancial instruments and the elimination of ceilings on deposit rates (re-)linked saving decisions to market interest rates, which justi…es our assumption about the change in asset market participation across the two periods. This is further supported by evidence from the 1983 Survey of Consumer Finances data on asset holdings and net worth. Table 8 therein shows that from 1970 to 1983 the percentage of families holding certi…cates of deposit changed from 8 to 20, for money market accounts from 0 to 14, while for other assets such as stocks and bonds the distribution of ownership is roughly stable[8]. Table 5 in the Second report shows that the percentage of families with net worth less than 10.000 USD changed from 56% to 38% (see Wol¤ and Caner [2002] for a careful study of asset-poverty dynamics using post-1984 PSID data). Finally, the New York Stock Exchange reports that the proportion of U.S. families holding shares has almost doubled over the period 1975-1985 (see NYSE [1986]). Duca [2001] presents further evidence that the decline in transaction costs (e.g. mutual fund loads, brokerage fees, and cost of exchange-traded funds) led to more widespread asset holding since the early 1980s. Jones [2002] also shows -see his Fig. 3 and 4- that commissions and spreads for shares at the NYSE have declined abruptly in the late 1970s and early 1980s (e.g., one-way transaction costs declined from about 1.20 percentage points in the

[6]Among them: a. consumer assets (saver certi…cates, money-market MM mutual funds, ceiling-free MM certi…cates, NOW and super-NOW accounts, MM deposit account); b. consumer credit and mortgages (equity access accoutns, secondary mortgage market, ‡oating-rate loans, leasing and ‡exible credits, variable rate mortgages and consumption installment loans); c. Treasury securities (variable rate bonds, adjustable-rate Fannie MAE, etc.); d. Tax-exempt securities; e. corporate bonds (deep-discound bonds, zero coupon and variable-rate bonds, bonds with warrants and IR swaps); f. futures and options on cash market instruments, stock market indices, etc.

[7]Followed by the Garn-StGermain Act reinforcing such de-regulatory provisions.

[8]The holding of bonds and especially stocks became much more widespread especially in the 1990s - see Guiso, Haliassos and Japelli [2003].

mid 70s to 0.60 in the early 80s). Corroborated with the phasing out of regulation Q such that savings account started actually making the market interest rate, all these arguments complete our justi...cation for believing that the U.S. economy before 1980 was marked by relatively more limited asset markets participation.

In summary, we have presented evidence that: 1. the vast majority of assets classi...ed now as wealth simply did not exist prior to the early 1980s (money market instruments, IRAs, NOW accounts, Treasury securities, corporate bonds, etc.); 2. of those that existed, some - such as checking accounts- were making zero interest rates, others -saving accounts- were not making the market interest rate due to Regulation Q and yet others (Treasury bills) were subject to binding quantitative restrictions discouraging their holding; 3. house equity could not be used for consumption-smoothing purposes since there was no secondary mortgage market and consumer credit only developed during this period; 4. shareholding changed signi...cantly. We have argued that a signi...cant structural change occurred in the late1970s and early 1980s, as legislation adopted by the Congress (the DIDMCA) suggests.

2. Limited asset market participation, Keynes and the IS curve: theory and some evidence.

In this section we brie‡y outline a theory that allows the analysis of monetary policy under limited asset market participation while treating the degree of asset market participation as a parameter that can be exogenously in‡uenced by policy, consistently with the evidence presented above. The framework is a modi...cation of the -by now- standard dynamic sticky-price cashless general equilibrium model, similar to the workhorse model in e.g. Woodford [2003, $Ch.$4] or CGG [1999]. The modi...cation is that we allow for limited asset markets participation, or 'segmented asset markets': part of the agents trade in complete asset markets including a market for shares in ...rms, while the other agents do not trade any assets and hence receive only a wage income. The share of non-asset holders, say λ, is exogenous, as in e.g. Alvarez, Lucas and Weber [2001][9]. These agents will fail to smooth consumption as in Mankiw [2000] or GLV [2003b], where this comes from the failure to accumulate physical capital.

The model outlined here is related to the framework in GLV [2003b] and Bilbiie [2003], but in contrast to the former it abstracts from capital accumulation and focuses on a di¤erent set of questions; namely, we study how the presence of non-asset holders alters: the slope of the aggregate Euler equation (IS curve), determinacy properties of interest rate rules, optimal monetary policy and the response of the model economy to various fundamental shocks[10]. Moreover, we use our theoretical insights to re-interpret the Great In‡ation episode in the US. This framework is more suitable for our exercise for at least four reasons. First, it emphasizes the

[9] Our model shares with Alvarez, Lucas and Weber [2001] only the structure of asset markets. Their paper focuses on a completely di¤erent question, i.e. the presence of a liquidity e¤ect under market segmentation. In their framework, all agents hold currency, whereas our model is cashless. Finally, our model incorporates a Philips curve relationship. Note that had we introduced money in the same way as the abovementioned paper, our model would be consistent with a liquidity e¤ect.

[10] GLV [2003b] are the ...rst to study determinacy properties of interest rate rules when some agents do not hold capital, but their analysis relies on numerical simulations and is much complicated by the presence of capital - which can by itself change determinacy properties dramatically.

effect of non-asset holders on aggregate demand, which we wish to test empirically. Second, it derives analitically the 'Inverted Taylor Principle' as a generically necessary condition for both equilibrium uniqueness and optimal policy when enough agents do not participate to asset markets. Third, it is directly comparable with and nests as a special case models such as CGG [2000] and Lubik and Schorfheide [2004], which interpret the Great Inflation episode using estimated policy rules and comparing them to prescriptions dictated by theoretical models, an exercise we wish to pursue here too. Fourth, the absence of capital accumulation allows us to obtain analytical results and be transparent about the mechanism at work. Notably, optimal policy can be analyzed in a tractable way.

The exposition here is stripped down to the essential. Suppose aggregate expenditure consists of consumption only. There are two types of households: asset holders indexed by S, trading state-contingent assets and shares in firms and non-asset holders indexed by H, who do not participate in any of the asset markets and simply consume their current income[11]. The shares of these agents are $1 - \lambda$ and λ respectively and are assumed to be constant. Total consumption in log-linear deviations from steady state is given by $c_t = \lambda c_{H,t} + [1 - \lambda] c_{S,t}$, where $c_{j,t}$ is consumption of group j.[12] Suppose furthermore for simplicity that labor supply of non-asset holders is inelastic $n_{H,t} = 0$, such that their consumption is equal to the real wage $c_{H,t} = w_t$ and total labor supply is given by $n_t = [1 - \lambda] n_{S,t}$. Assume that asset holders' labor supply obeys a standard optimality condition $\varphi n_{S,t} = w_t - c_{S,t}$, where φ is the inverse Frisch elasticity of labor supply for type S. Total consumption will hence be: $c_t = \lambda w_t + [1 - \lambda] c_{S,t} = \lambda \varphi_S n_{S,t} + c_{S,t} = \frac{\lambda}{1-\lambda} \varphi n_t + c_{S,t}$.Finally, assume that the production function for final output in log-linear form is $y_t = [1 + \mu] n_t + [1 + \mu] a_t$, where μ represents both the steady-state net mark-up and the degree of aggregate increasing returns to scale[13] and a_t is log exogenous technology. Using this we obtain a version of the 'planned expenditure' (or 'aggregate demand') equation from standard Keynesian models (see for example David Romer's textbook)[14]:

$$c_t = c\left(\underset{+}{y_t}, \underset{-}{rr_t}\right) = \frac{\lambda}{1-\lambda}\frac{\varphi}{1+\mu} y_t + c_{S,t} - \frac{\lambda}{1-\lambda}\varphi a_t \tag{2.1}$$

This equation links aggregate expenditure to current income, consumption of asset holders and exogenous technology. Note that (2.1) is not a reduced-form relationship since $c_t, y_t, c_{S,t}$ are all endogenous variables, which will be determined in general equilibrium. However, we can think of (2.1) as a schedule in the (y, c) space, for a given level of $c_{S,t}$. In that sense, we can say that aggregate demand (expenditure) depends positively on current income and negatively on the real interest rate. We can define the (partial) 'marginal propensity to consume' out of current income as $\partial c/\partial y = \frac{\lambda}{1-\lambda}\frac{\varphi}{1+\mu} > 0$. This 'marginal propensity to consume' is in fact

[11]In the background of non-participation in asset markets there could be many reasons (constraints or preferences); but as long as all reasons have the same observational consequence, their relative importance is immaterial for our purposes. Our preferred explanation consists of constraints such as transactions costs; recent theoretical and empirical research shows that such market frictions alone could account for the observed participation shares (see e.g. Vissing-Jorgensen (2003), He and Modest (1995)).

[12]This approximation only holds if steady-state consumption shares of the two types are equal, i.e. asset income is zero in steady-state. This will be insured by appropriate conditions on the production side.

[13]This insures that asset income is zero in steady-state, so that all algebra here is consistent.

[14]I thank Jordi Galí for having suggested the Keynesian cross interpretation.

a partial marginal propensity, i.e. keeping fixed consumption of asset holders c_S. In equilibrium, of course, all output is consumed. We will loosely refer to $\partial c/\partial y$ as 'marginal propensity to consume' in the remainder. The negative impact of ex-ante real interest rates $rr_t \equiv r_t - E_t\pi_{t+1}$ on aggregate demand comes from a standard Euler equation for consumption of asset-holders: $c_{S,t} = E_t c_{S,t+1} - [r_t - E_t\pi_{t+1}]$, where r is the nominal interest rate and the intertemporal elasticity of substitution in consumption is normalized to one without loss of generality.

The marginal propensity to consume is increasing in (i) the share of non-asset holders λ, for this means that a higher fraction of total population simply consumes the real wage and is insensitive to interest rate movements and (ii) the extent to which labor supply is inelastic φ, for this implies that small variations in hours (and output) are associated to large variations in real wage and hence in the consumption of non-asset holders. Hence, (2.1) is consistent with Keynes' views that the aggregate propensity to consume depends on 'the principles on which income is divided between the individuals composing [the community] - which may suffer modification as output is increased' and further that 'we may have to make an allowance for the possible reactions of aggregate consumption to the change in the distribution of a given real income between entrepreneurs and rentiers resulting from a change in the wage-unit' (Keynes [1935], Chapter 8, Book III).

Together with the condition that consumption equal output $c_t = y_t$, equation (2.1) leads to a 'Keynesian cross'-type diagram and the standard IS equation in case $\partial c/\partial y < 1$. However, note that the marginal propensity to consume out of current output $\partial c/\partial y$ can become greater than one for high values of λ and/or φ, namely when

$$\lambda > \lambda^* = \frac{1}{1 + \varphi/(1+\mu)}. \tag{2.2}$$

This is the case when there are enough agents who consume their wage income w, and the latter is sensitive enough to current total income y (labor supply is inelastic enough). Aggregate marginal propensity to consume (again, for a given c_S) can be larger than one since non-asset holders consume all their current income given by the real wage, which is instead related to total output (income) more than one-to-one (and the more so, the more inelastic is labor supply).

We label this case 'non-Keynesian' since Keynes belived a marginal propensity to consume less than unity to be 'a fundamental psychological law'. However, it should be noted that the aggregate implications of (2.2) do not necessarily contradict Keynes' views, as argued below (the difference coming from our definition of a marginal propensity given c_S). We plot (2.1) in this case along with the $c = y$ schedule in the 'Non-Keynesian cross' in Figure1, where an increase in the real interest rate moves the (2.1) schedule rightward (by intertemporal substitution) leading to higher consumption and output.

Figure 1 here.

An immediate implication of (2.2) is that the slope of the aggregate IS curve changes sign. Start by expressing consumption of asset holders as a function of output from (2.1) imposing that in equilibrium total expenditure equals actual output, $c_t = y_t$:

$$c_{S,t} = \delta y_t + (1+\mu)(1-\delta)\, a_t, \text{ where } \delta \equiv 1 - \frac{\lambda}{1-\lambda}\frac{\varphi}{1+\mu} \tag{2.3}$$

and note that $\delta < 0$ when $\partial c/\partial y > 1$, i.e. in the non-Keynesian case. Consumption of asset holders can be negatively related to total output since an increase in demand can only be satisfied by movements of (as opposed to movements along) the labor supply schedule when enough people hold no assets and labor supply is inelastic enough. But the necessary rightward shift of labor supply can only come from a negative income effect on consumption of asset holders. This negative income effect is ensured in general equilibrium by a potential fall in dividend income. Note that asset holders have in their portfolio $(1-\lambda)^{-1}$ shares: if total profits fell by one unit, dividend income of one asset holder would fall by $(1-\lambda)^{-1} > 1$ units[15]. The potential decrease in profits is a natural result of inelastic labor supply, since the increase in marginal cost (real wage) would more than outweigh the increase in sales (hours). Therefore, (2.1) and (2.3) are consistent with Keynes' [op.cit.] statement that 'the consumption of the wealth-owning class may be extremely susceptible to unforeseen changes in the money-value of its wealth'.

However, it is important to note that this negative income effect does not mean that for a given increase in output, the consumption of asset holders will necessarily decrease in equilibrium. In fact, if the increase in output is due to technology, c_S will increase in most cases (i.e. when the equilibrium elasticity of output to technology is less than $(1+\mu)\left(1-\delta^{-1}\right)$). Moreover, precisely due to the negative income effect making asset holders willing to work more, it may also be the case that actual profits do not fall - since hours will increase by more and marginal cost by less. In fact, for certain configurations of shocks and parameters, the equilibrium of our model would not imply countercyclical profits (or at least implies more procyclical profits than a standard full-participation model with countercyclical markups). This is an important point, since it is widely believed that profits are procyclical.

Substituting (2.3) into the Euler equation we obtain the aggregate IS curve:

$$y_t = E_t y_{t+1} - \delta^{-1}\left[r_t - E_t\pi_{t+1}\right] + (1+\mu)\left(\delta^{-1} - 1\right)\left[E_t a_{t+1} - a_t\right]. \tag{2.4}$$

This schedule has a positive slope when $\delta < 0$, consistent with the intuition above. This modifies drastically determinacy properties and optimal design of interest rate rules and the economy's response to shocks, as argued below. While we label the case where $\delta < 0$ 'non-Keynesian' (for it corresponds to a 'marginal propensity to consume' larger than one, which Keynes viewed as implausible) it should be emphasized that Keynes in fact believed that the impact of real interest rates on aggregate spending is not necessarily negative, since it depends on many contradicting factors. Among these, he in fact hints to 'the appreciation or depreciation in the price of securities', which is at the heart of our mechanism[16].

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[15] In the standard model all agents hold assets, so this mechanism is completely irrelevant. Any increase in wage exactly compensates the decrease in dividends, since all output is consumed by asset holders.

[16] 'The influence of this factor (the rate of interest) on the rate of spending out of a given income is open to a good deal of doubt. For the classical theory of the rate of interest, which was based on the idea that the rate of interest was the factor which brought the supply and demand for savings into equilibrium, it was convenient to suppose that expenditure on consumption is cet. par. negatively sensitive to changes in the rate of interest, so that any rise in the rate of interest would appreciably diminish consumption. It has long been recognised, however, that the total effect of changes in the rate of interest on the readiness to spend on present consumption is complex and uncertain, being dependent on conflicting tendencies, since some of the subjective motives towards saving will be more easily satisfied if the rate of interest rises, whilst others will be weakened. [...] Indirectly there may be more effects, though not all in the same direction. Perhaps the most

We can express (2.4) in a more familiar and compact form as follows. Notice that real wage is related to output according to: $w_t = \chi y_t - \varphi a_t, \chi \equiv 1 + \varphi / (1 + \mu)$, so real marginal cost is $mc_t = \chi y_t - (1 + \varphi) a_t$. If prices were perfectly flexible, real marginal cost would be constant $mc_t^* = 0$, and hence the 'natural' level of output is given by $y_t^* = [(1 + \varphi) / \chi] a_t$. Using this to express (2.4) in terms of output gap x_t (defined as deviations of actual from natural output, $y_t - y_t^*$) we obtain:

(2.5) $$x_t = E_t x_{t+1} - \delta^{-1} [r_t - E_t \pi_{t+1} - r_t^*].$$

In (2.5) we used the natural rate of interest r_t^*, defined as the interest rate consistent with output being at its natural level (and zero inflation) as in Woodford [2003]: $r_t^* \equiv [1 + \mu (1 - \delta/\chi)] [E_t a_{t+1} - a_t]$. Note that the natural interest rate increases with technology growth shocks.

2.1. The changing sign of IS curve's slope: some evidence. One directly testable implication of our model concerns the change in the sign of the IS curve' slope: a change in asset market participation as suggested in Section 1 implies that the elasticity of aggregate demand to real interest rates has changed sign during the same period as the Volcker disinflation. To our knowledge, there is no study documenting such a change. Moreover, surprisingly little work has been done on estimating the 'IS curve', i.e. an Euler equation for output of the form (2.5). Fuhrer and Rudebusch [2003] is to our knowledge the first paper to estimate such equations (see also Fuhrer and Olivei [2004]). In this section, we follow these papers closely in regards of data and estimation methods.

We build on this approach to assess the structural stability of the IS curve over the post-1965 period[17]. We present evidence that a significant change in the sensitivity of aggregate demand to interest rates occurred in the 1979-1982 period. This evidence comes from a few sources: (i) estimates over the subsamples 1965-1979 and 1982-2003; (ii) recursive estimations; (iii) test for structural change. We will follow Fuhrer and Rudebusch in using exactly the same dataset, variables, and estimation method, although we do not report all the robustness checks due to lack of space. We estimate by the Generalized Method of Moments (GMM) the following 'expanded' output Euler equation[18]:

(2.6) $$x_t = a_0 + a_1 x_{t-1} + a_2 x_{t-2} + b E_t x_{t+1} + d E_{t-\tau} \left[\frac{1}{k} \sum_{j=0}^{k-1} (r_{t+j+m} - \pi_{t+j+m+1}) \right] + \eta_t.$$

This form generalizes the simple Euler equation over four dimensions discussed in detail in Fuhrer and Rudebusch: influence of lagged terms of the output gap, flexible

important influence, operating through changes in the rate of interest, on the readiness to spend out of a given income, depends on the effect of these changes on the appreciation or depreciation in the price of securities and other assets. For if a man is enjoying a windfall increment in the value of his capital, it is natural that his motives towards current spending should be strengthened, even though in terms of income his capital is worth no more than before; and weakened if he is suffering capital losses.' [Keynes op.cit.]

[17]Following Fuhrer and Rudebusch we choose 1965 as a starting date since only thereafter did the federal funds rate act as the primary instrument of monetary policy.

[18]Fuhrer and Rudebusch also provide Monte Carlo evidence that GMM estimates are more likely to be subject to bias than maximum likelihood estimates. However, as the evidence in their paper indicates, this objection is particularly binding for estimates of the parameter b, i.e. the coefficient on future output. The evidence on the interest-rate elasticity d is at best mixed.

timing of expectation formation (τ)[19], in‡uence of past real rates (captured by m), and ‡exible interest rate duration (governed by k). In the …rst set of estimations, we perform robustness checks for di¤erent measures of potential output used when calculating output gap: (i) a Hodrick-Prescott …lter; (ii) a segmented linear trend with one break; (iii) a segmented trend with two breaks; (iv) a quadratic trend; (v) a segmented quadratic trend; (vi) the measure of the Congressional Budget O¢ce (CBO); (vi) one-sided band-pass …lter (BP2). For most of the remainder of our analysis, we will focus on one (the most widely used) proxy for the output gap x_t, deviations of GDP from an HP …lter. r_t is the quarterly average of the overnight federal funds rate and in‡ation the annualized log change in the price index[20]. One issue concerns the instrument set to be used for estimations: following Fuhrer and Rudebusch and Fuhrer and Olivei we use four lags of the output gap, federal funds rate and in‡ation; when checking for robustness, we also use their same set of exogenous instruments: (four lags of) real defense expenditure, relative oil prices and the political party of the sitting U.S. President.

For a …rst test, we perform estimations of the 'theoretical IS curve' (i.e. $a_1 = a_2 = 0, k = 1, m = 0$ such that d strictly corresponds to ¡$\delta^{¡1}$). We estimate the equation over the two subsamples: the 'Great In‡ation' period, 1965:4-1979:3 and the Volcker-Greenspan period excluding the Volcker disin‡ation, 1983:1-2003:1. We exclude the Volcker disin‡ation period for comparison with the studies performing this sample-splitting exercise for monetary policy rules, such as CGG [2000]. Results, reported in Table 1 show estimates of the coe¢cients with standard errors, and the p-value from Hansen's J-test. The estimates show a possible change in the sign of the interest rate sensitivity of aggregate demand from a positive value corresponding to our 'Non-Keynesian economy' scenario to a negative value, consistent with standard theory and policy prescriptions. At the same time, the coe¢cient on expected output gap is almost always close to unity, as expected from theory. The instruments seem to be valid as judged by the J-test. The results are reassuringly robust to the output gap measure used, to whether contemporaneous or lagged interest rate is included and to the instrument set.[21]

Table 1 here.

Fuhrer and Rudebusch argue that testing for the simplest version of the IS curve might be marked by misspeci…cation, due to the absence of other potentially relevant dynamic e¤ects such as those embodied in (2.6) and described before. They indeed …nd that lagged terms of the output gap and are signi…cant economically and statistically, and the coe¢cient on expected output gap is signi…cantly lower than one. However, their interest rate sensitivity d was insigni…cantly di¤erent from zero for most estimations for the whole sample, no matter the timing and duration of interest rate used, the output gap measure or the instrument set. Hence, we also estimate the linear equation (2.6) by GMM[22] and try to assess the stability of this parameter. The equation we are now estimating is no longer the same as

[19]For GMM estimation, this is implicitly given by the timing of instruments: e.g., τ=1 when lags of the instruments are considered.

[20]Note that the interest rate used in the estimation is sometimes (when k=4) the four-quarter moving average.

[21]Not all permutations are reported in the table, but this result carries over to most of the possible combinations of interest rate timing, output detrending method and instrument set used.

[22]Fuhrer and Rudebusch also perform MLE estimation and show that it performs better as far as estimation of the forward-looking coe¢cient is concerned. The two methods lead to similar

its theoretical counterpart (2.5), due to the presence of lagged terms in output gap (coming in theory from habit persistence or lags in expenditure decisions) and of different timing and duration of interest rates. Such features, when incorporated into the theoretical model, would most likely lead to different conclusions than our simple framework. Hence, we can neither attempt to estimate the structural parameters directly, nor map changes in d to changes in $-\delta^{-1}$ (the theoretical elasticity) directly. However, we believe that a directional change in the empirical elasticity is informative of the type of structural change contemplated in the U.S. economy. Results are reported in Table 2, where for lack of space we only deal with HP-filtered output gap and endogenous instruments. The sensitivity of aggregate demand to interest rates (for various timing and duration of the latter) is positive and significant, providing further support for our 'Non-Keynesian economy' scenario.

Table 2 here.

To grasp the evolution over time of the estimated d, we perform a set of recursive estimations. For the remainder of the analysis we focus on the richer specification (2.6), using HP-filtered output gap, endogenous instruments and the interest rate corresponding to $k = 4, m = -1$. First, we report 'increasing sample' estimates of the d parameter, i.e. estimates obtained by running the GMM estimation for an initial sample of 50 observations, and then augmenting the sample by one observation at each iteration. The results reported in Figure 2 (together with error bands of two standard errors) show a sharp decrease in the coefficient from a positive significant value to a value close to zero. Hence, we may conclude that the 1965-1979 subsample is very different from the rest. To complete the recursive estimations, we also report rolling estimates in Figure 3, i.e. estimates of d using a rolling window of 60 observations running from the beginning to the end of the sample. As expected, there is evidence of instability, with positive coefficient in the earlier subsamples.

Figures 2 and 3 here.

In order to test more rigorously for a structural break in the d coefficient, we employ the Wald test proposed by Andrews [1993] for GMM estimators. This test is designed to find a structural change when the date of the change is unknown. The null hypothesis of the test is parameter stability, and is rejected for large values of the statistic. The statistic is constructed by splitting the sample into two parts, calculating the coefficients and the corresponding variances and then moving the threshold towards the end of the sample and repeating the exercise. A value of the statistic is found at each iteration; the test is a 'sup' test, so the date with the largest statistic is the date where it is most likely that the change occurred. Statistical significance can be judged using the critical values calculated by Andrews. Figure 4 reports the Wald statistic for coefficient d, where we look for the break over the whole sample (excluding the first and last 47 observations). The statistic clearly suggests that there is a change in the coefficient around quarter 21, which added to the initial 47 observations leads to 1981:1 as the suggested break. The other high values of the statistic are obtained starting from around 1979. This is relatively robust to searches performed over different samples, with different timing and duration of the interest rate. The break (as indicated by this test) is always inside the 1979-1982 period.

Figure 4 here.

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results as far as the interest rate sensitivity is concerned, hence we stick to the simpler GMM method.

3. The 'inverted Taylor principle' and optimal passive monetary policy

In this Section we ask what implications does the evidence outlined above (of relatively more limited participation in the pre-Volcker period, so limited that the IS curve had a positive slope) have for Fed's policy. We will show that in our theoretical model, an IS curve sloping in the 'wrong' way implies that policy ought to be passive, as Fed policy was found to be in the pre-Volcker period by many studies, for a variety of reasons having to do with stability and welfare. We will also argue that when the IS curve's slope changes sign, optimal policy switches endogenously from passive to active - much like Fed's policy has changed in the early 1980s.

To be able to analyze monetary policy and draw normative conclusions, we need to complement the IS curve (2.5) by an equation for inflation dynamics and one for interest rate setting in order to close our model. As regards inflation dynamics, we follow an enormous recent literature and assume that prices are sticky (see Woodford (2003) and Galí (2002) for comprehensive studies of this framework). This provides a by now well-understood, simple benchmark for the analysis of monetary policy and makes our model easy to compare to other theories. Assume for instance that prices are sticky a la Calvo, whereby a history-independent fraction of firms θ is unable to reset prices. This gives rise to the well-known 'New Philips curve' relating actual to expected inflation and marginal cost: $\pi_t = \beta E_t \pi_{t+1} + \psi mc_t$, where β is the discount factor and $\psi \equiv (1 - \theta)(1 - \theta\beta)/\theta$. In the absence of any disturbances breaking this link, marginal cost and the output gap x_t are related by: $mc_t = \chi x_t$. We break this link (following CGG [1999] or Woodford [2003]) by assuming the presence of the cost-push shocks[23] u_t such that $mc_t = \chi x_t + \psi^{-1} u_t$. Hence, inflation π_t is related to its expected value and output gap x_t by[24]:

$$\pi_t = \beta E_t \pi_{t+1} + \kappa x_t + u_t, \text{where } \kappa \equiv \psi\chi. \tag{3.1}$$

The model is closed by specifying how monetary policy is conducted. We will study two alternative settings: a simple interest rate rule, and optimal (welfare-maximizing) monetary policy. For the former, we consider rules involving a response to expected inflation, as done for example by CGG [2000] (capturing the idea that central banks respond to a larger set of information than merely the current inflation rate):

$$r_t = \phi_\pi E_t \pi_{t+1} + \varepsilon_t. \tag{3.2}$$

where ε_t is the non-systematic part of policy-induced variations in the nominal rate. We abstract from interest rate smoothing and a response to output. This specification provides simpler determinacy conditions and makes the mechanism behind the theoretical results fully transparent. Such extensions could be easily incorporated at the cost of losing this simplicity.

An immediate implication of the change in the sign of δ^{-1} is that the stabilization properties of monetary policy are inverted. Recent research in monetary

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[23] These can represent variations in the price markups coming from time-varying elasticity of substitution between intermediate goods, variations in wage markups, distortionary taxation or other time-varying inefficiency wedges - see Woodford (2003, Ch 3) for details.

[24] The New Philips curve is not influenced by the presence of non-asset holders only because steady-state profit income is zero. This is not the case in the more general set-up, but the differences are not crucial for the mesage of our paper.

policy argues that in order to ensure macroeconomic stability in the standard, full-participation framework, monetary policy needs to increase nominal rates systematically more than one-to-one for a given increase in in‡ation (be 'active'). If nominal interest rates are set according to (3.2), when $\delta - 1 > 0$ the response coe¢cient needs to ful…ll what Woodford (2001) has labeled 'the Taylor principle': $\phi_\pi > 1$. This ensures equilibrium determinacy when prices are set on a forward-looking basis[25]. Intuitively, a sunspot shock (increasing expected in‡ation for no fundamental reason) has no e¤ects since by triggering an increase in the real rate it leads to a fall in aggregate demand (from (2.5)). This instead means that actual in‡ation will decrease (by the Philips curve), contradicting the initial non-fundamental expectation.

Clearly, in the non-Keynesian case $\delta < 0$, an 'Inverted Taylor principle' holds; in order to ensure stability, monetary policy needs to be passive[26]:

$$\phi_\pi < 1.$$

In the Non-Keynesian economy ($\delta < 0$) a non-fundamental increase in expected in‡ation generates an increase in the output gap today if the policy rule is active ($\phi_\pi > 1$) as can be seen from (2.5). If a Philips curve holds, this means that in‡ation today increases, making the initial non-fundamental beliefs self-ful…lling. How does a passive policy rule ensure equilibrium determinacy? A non-fundamental increase in expected in‡ation causes a fall in the real interest rate, a fall in the output gap today by (2.5) and de‡ation, contradicting to the initial expectation. At a more micro level, the transmission is as follows. The fall in the real rate leads to an increase in consumption of asset holders, and an increase in the demand for goods; but note that these are now partial e¤ects. To work out the overall e¤ects one needs to look at the component of aggregate demand coming from non-asset holders and hence at the labor market. The partial e¤ects identi…ed above would cause an increase in the real wage (and a further boost to consumption of non-asset holders) and a fall in hours. Increased demand, however, means that (i) some …rms adjust prices upwards, bringing about a further fall in the real rate (as policy is passive); (ii) the rest of …rms increase labor demand, due to sticky prices. Note that the real rate will be falling along the entire adjustment path, amplifying these e¤ects. But since this would translate into a high increase in the real wage (and marginal cost) and a low increase in hours, it would lead to a fall in pro…ts, and hence a negative income e¤ect on labor supply. The latter will then not move, and no in‡ation will result, ruling out the e¤ects of sunspots. This happens when asset markets participation is limited 'enough' in a way made explicit by (2.2)[27].

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[25] Formally, one puts together equations (2.5) and (3.1), having replaced (3.2) and looks at the eigenvalues of this dynamic system. Since both in‡ation and output are forward-looking variables, both eigenvalues need to be larger than one for equilibrium to be determinate. When this is not the case, equilibrium is indeterminate, and sunspot shocks have real e¤ects.

[26] This condition is necessary and su¢cient if the Philips curve reads merely: $\pi_t = x_t$. With the forward-looking Philips curve, this condition is su¢cient under somehwat more restrictive conditions on λ. For a full-‡edged determinacy discussion see Bilbiie [2003], where su¢cient conditions are also provided. He shows that this result holds generically, i.e. for rules responding to current in‡ation, as well as for rules responding to output gap under more restrictive conditions.

[27] This insight is robust to a more general model featuring the accumulation of physical capital, as numerical simulations presented by GLV [2003*b*] suggest for a forward-looking rule like (3.2). For di¤erent policy rules (such as involving a response to actual in‡ation) the determinacy properties are somewhat modi…ed.

How does the presence of non-asset holders alter the optimal design of monetary policy rules in the simple model sketched above? To address this question we use a welfare-based quadratic loss function derived for our model with two types of agents. We make a series of assumptions common in the literature that render these second-order approximation techniques valid (see Woodford [2003] or Galí and Monacelli [2004]). Firstly, we assume that e¢ciency of the steady state is obtained by appropriate …scal instruments inducing marginal cost pricing in steady state (subsidies for sales at a rate equal to the stead-state net mark-up …nanced by lump-sum taxes on …rms). Since this policy makes steady-state pro…t income zero, the steady-state is also equitable: steady-state consumption shares of the two agents are equal, making aggregation much simpler. This ensures consistency with the model outlined above[28]. Secondly, we assume that the social planner maximizes (the present discounted value of) a convex combination of the utilities of the two types, weighted by the mass of agents of each type[29]. A complete derivation for a more general case is detailed in Bilbiie [2003]. The quadratic approximation of the objective function around the e¢cient ‡exible-price equilibrium yields:

$$U_t = -\frac{1}{2} E_t \sum_{i=t} \left\{ \alpha x_{t+i}^2 + \frac{\psi}{\varepsilon} \pi_{t+i}^2 \right\}, \tag{3.3}$$

$$\alpha = \frac{1+\varphi}{1-\lambda}. \tag{3.4}$$

Note that when $\lambda = 0$ the weight on output gap stabilization collapses to the standard one: $\alpha = 1 + \varphi$. In general, the relative weight on output gap is increasing in the share of non-asset holders. When the share of non-asset holders tends to one, the relative weight on output stabilization tends to in…nity. Hence, the presence of non-asset holders modi…es the trade-o¤ faced by the monetary authority. The intuition for this result is simple: relative price dispersion (related here linearly to squared in‡ation) erodes aggregate pro…t income for given levels of output and marginal cost. Given that only a fraction of $(1 - \lambda)$ receives pro…t income, when this fraction tends to zero the welfare-based relative weight on in‡ation (price dispersion) also tends to zero.

The optimal discretionary rule $\{r_t^o\}_0^{\infty}$ is found by minimizing $-U_t$ taking as a constraint the IS-AS system, and re-optimizing every period[30]. Note that by usual arguments this equilibrium will be time-consistent. This is, up to interpretation of the solution, isomorphic to the standard problem in CGG (1999). Hence, for brevity, we skip solution details available elsewhere and go to the result:

$$x_t = -\frac{\kappa\varepsilon}{\alpha\psi}\pi_t = -\frac{\chi}{1+\varphi}\varepsilon(1-\lambda)\pi_t \tag{3.5}$$

[28]Note, however, that since steady-state consumption shares are equal we do not need to assume increasing returns. Under these assumptions, the reduced-form coe¢cients simply modi…y as follows: $\chi^o = 1 + \varphi$ and $\delta^o = 1 - \varphi\lambda/(1-\lambda)$.

[29]This is consistent with our view that limited participation to asset markets comes from constraints and not preferences, since in the latter case maximizing intertemporally the utility of non-asset holders would be hard to justify on welfare grounds. However, note that for the discretionary Markov equilibrium studied here, this choice makes no di¤erence since terms from time $t+1$ onwards are treated parametrically in the maximization and the time-t objective function is identical.

[30]To keep things simple, we focus on the discretionary, and not fully optimal (commitment) solution to the central banker's problem. This case can be argued to be more realistic in practice, as do CGG (1999).

Note that the policy needs to conform the same principle as in the standard model: when inflation increases (decreases) the central bank has to act in order to contract (expand) demand. Assuming an AR(1) process for the cost-push shock $E_t u_{t+1} = \rho_u u_t$ for simplicity, we obtain the following reduced forms for inflation and output from the aggregate supply curve:

(3.6)
$$\begin{aligned} \pi_t &= \alpha \frac{\psi}{\kappa^2 \varepsilon + \alpha \psi (1 - \beta \rho_u)} u_t \\ x_t &= -\kappa \frac{\varepsilon}{\kappa^2 \varepsilon + \alpha \psi (1 - \beta \rho_u)} u_t \end{aligned}$$

Substituting the expressions given by (3.6) into the IS curve, we obtain the implicit instrument rule consistent with optimality:

(3.7)
$$\begin{aligned} r_t^o &= r_t^* + \phi_\pi^o E_t \pi_{t+1}, \\ \phi_\pi^o &= 1 + \delta \chi \varepsilon \frac{1-\lambda}{1+\varphi} \left(\frac{1-\rho_u}{\rho_u} \right). \end{aligned}$$

The optimal response to inflation is decreasing in the share of non-asset holders $\frac{\partial \phi_\pi^o}{\partial \lambda} < 0$. Three implications regarding optimal policy are worth stressing:

(1) Since α is increasing in λ, in an economy with limited asset market participation optimal policy results in greater inflation volatility and lower output gap volatility than in a full participation economy ($\lambda > 0$) - this can be seen directly from (3.6). Optimal policy in this case requires more output stabilization at the cost of accommodating inflationary pressures.

(2) In a non-Keynesian economy ($\delta < 0$) the implied instrument rule for optimal policy is passive $\phi_\pi^o < 1$. In order to contract demand when inflation increases as required by (3.5), the central bank must move nominal rates such that the real rate decreases.

(3) The optimal response to inflation switches from passive to active when the degree of asset markets participation changes such that δ changes sign from negative to positive. This suggests that the response of the Fed to inflation may have changed endogenously from passive to active in the late 1970s, due to the change in asset market participation.

Finally, notice that for a given estimated response to inflation $\hat{\phi}_\pi$ (and given the other deep parameters of the model), we can calculate the implied degree of asset market non-participation $\hat{\lambda}$ which would justify as optimal the particular estimated rule considered. This is done by merely solving for $\hat{\lambda}$ from (3.7) as:

$$\hat{\lambda} = \frac{1}{\chi} \left[1 - \frac{\left(\hat{\phi}_\pi - 1 \right) \rho_u}{\varepsilon (1 - \rho_u)} \right].$$

In summary, we have outlined a theory that indicates the desirability of passive interest rate rules when part of the agents do not participate in asset markets and do not smooth consumption. This desirability obtains for two related reasons: (i) ensuring equilibrium determinacy and ruling out potentially welfare-damaging sunspot fluctuations and (ii) welfare maximization.

Moreover, we have suggested that when the degree of asset market participation changes, optimal policy should also change. In particular, the optimal response to inflation switches endogenously from passive to active when δ changes sign. If in the 1970s asset markets participation in the United States was exceptionally limited such that the IS curve had the 'wrong' sign, one can conclude that monetary policy during the period was better than conventional wisdom dictates.

4. Theoretical predictions meet stylized facts

In this section we perform a quantitative exercise, studying the implications of the model outlined above for responses to shocks and moments of variables of interest, and comparing these implications to stylized facts. We will allow for changes in two parameters across samples, namely 1. the degree of asset market participation (based on the evidence above) and 2. the conduct of monetary policy (the responsiveness of interest rates to in‡ation). It is an almost consensual view that monetary policymaking changed with the coming to o¢ce of Paul Volcker. One instance of this is a change in estimated coe¢cients of interest rate rules. CGG [2000], Taylor [1999], Lubik and Schorfheide [2004] and Cogley and Sargent [2002] all reach such a conclusion. One is then tempted to attribute (at least part of) the change in dynamics of macro variables (mainly in‡ation and output) and their variability to such a change in policy[31]. Most importantly, since a passive rule leads to an indeterminate equilibrium in the models of CGG and Lubik and Schorfheide, these authors, among others, argue that part of in‡ation variability can be accounted for by sunspot shocks. However, the same authors show that sunspot shocks drive up both in‡ation and output (which is also the case in our 'Non-Keynesian economy'). If one wants to …nd an explanation for high in‡ation and recessions (features of the 1965-1980 period) sunspot shocks are not a good candidate. Fundamental shocks, on the other hand, cannot be studied in an indeterminate equilibrium as the one with a passive rule in the standard models: they can have virtually any e¤ects[32]. But if one assumes that asset markets participation was limited enough to ensure the 'Inverted Taylor principle' holds, one can study the e¤ects of fundamental shocks since equilibrium is determinate. This is the exercise we pursue here.

We study the responses and moments of macro variables under two di¤erent scenarios, corresponding to the pre-Volcker and Volcker-Greenspan subsamples. We parameterize the model at quarterly frequency and, with the exception of ϕ_π and λ discussed below, parameters are assumed to have been invariant across samples. The baseline case follows GLV [2003*b*] (except for the mentioned di¤erences) and most monetary policy studies. Namely, we set the discount factor β such that the stead-state interest rate is $r = 0.01$ and the steady state markup to $\mu = 0.2$. The steady-state share of pro…ts is brought to zero by setting a …xed cost in the intermediate goods sector whose output share is equal to the net mark-up $F_Y = \mu = 0.2$. The average price duration is one year, implying $\theta = 0.75$. The benchmark value

[31] Many authors have emphasized that increased variability may come from a di¤erent distribution from which shocks were drawn in that period - see Sargent [2002] and the studies by Sims and Bernake and Mihov quoted therein. This is likely to be an important explanation. But a change in variances of shocks, however, would not generate a change in shapes/signs of responses to shocks.

[32] CGG [2000] argue that even variability as explained by cost-push shocks is increased in a 'near-determinate' equilibrium, whereby the coe¢cient on in‡ation is slightly above one. Hence, this would explain increased variability and higher in‡ation from fundamentals. But this merely explains why in a determinate equilibrium with an active rule responding less to in‡ation results in higher variability of the latter. Dynamics in the indeterminate equilibrium are not pinned down.

of the inverse Frisch elasticity of labor supply φ is set to 2 implying an elasticity of 0.5. Notably, unless specified otherwise we keep the stochastic properties of shocks unchanged across the two periods normalizing standard deviations to unity. We consider a persistence of the cost-push shock of $\rho_u = 0.9$.

Finally, based on the discussion and evidence above, we consider the case whereby there are two parameters changing across the two periods: the response of interest rates to inflation ϕ_π, and the degree of asset markets participation λ. The policy rules are parameterized using estimates by CGG [2000] and Taylor [1999], namely $\phi_\pi = 0.8$ pre-Volcker and $\phi_\pi = 1.5$ for Volcker-Greenspan. The benchmark share of agents with no assets in the pre-Volcker period is taken to be $\lambda = 0.4$ (this is also the lower bound of the estimates of Campbell and Mankiw [1989]). For the Volcker-Greenspan period we consider a low value chosen arbitrarily, $\lambda = 0.05$. Some robustness checks are performed varying this parameter and the inverse elasticity of labor supply.

4.1. Cost-push shocks. Arthur Burns emphasized the cost-push nature of inflation in the 1970's time and again in various speeches and statements as documented e.g. in Hetzel [1999] and Mayer [1999]. Alan Blinder [1982] gives a careful account of the nature of the shocks and their impact on inflation. Mayer [1999] provides additional references. New research in the sticky-price dynamic general equilibrium vein finds that cost-push shocks have been the main cause of fluctuations in the pre-Volcker era. Ireland [2004] presents such evidence based on variance decompositions from a 'new synthesis' model estimated by maximum likelihood. A similar result is obtained by Lubik and Schorfheide [2004] using Bayesian estimation. Our first experiment studies the response of the economy to a unit cost-push shock under the two scenarios described above. Its purpose is to show that such a shock (even of the same magnitude) generates relatively much higher and more volatile inflation in the pre-Volcker scenario, while also generating a recession.

The impulse responses of various variables to a unit cost shock under the two scenarios are plotted in Figure 5 (circles for 'Non-Keynesian economy' and triangles otherwise). Indeed, the responses conform to both conventional wisdom and what we view as a good test for a theory purported to explain dynamics in that period: higher inflation, low real rates, and negative comovement of inflation and the output gap (since potential output is unaffected $y^* = 0$, the output gap x is equal to output y). Moreover, responses of output and inflation have the same sign under both scenarios, as shown analytically in Bilbiie [2003]. But the response of inflation is much larger in the pre-Volcker scenario. The response of the output gap is not much different, and the real rate is negative as expected, since the policy rule is passive. The Wicksellian rate is of course unchanged.

Figure 5 here.

Table 3 looks at conditional standard deviations of output gap, inflation and interest rates, normalizing standard deviations in the parameterized Volcker-Greenspan scenario to 1. The implied standard deviation of inflation and interest rates are much higher for the parameterized pre-Volcker period, confirming conventional wisdom and empirical findings, while the standard deviation of the output gap (and implicitly output) is slightly lower. For a first robustness check of this result, we perform the same exercise varying the share of non-asset holders. We consider two values for the inverse elasticity of labor supply, and for each such value we vary λ inside the corresponding interval for each period (i.e., for the pre-Volcker period,

λ goes from just above the threshold making the Inverted Taylor Principle work to a maximum value of 0.5; for the Volcker-Greenspan period, it goes from a very low value to just under the threshold). Results confirm that, generally, more conditional volatility (especially in inflation and nominal interest rates) results in the pre-Volcker economy, with a passive policy rule and lower asset markets participation ensuring equilibrium determinacy.

Table 3 and Table 4 here.

The last robustness check consists of shocking the model with all three shocks and looking at unconditional volatility for our baseline parameterization. First exercise keeps the variance of shocks unchanged across periods. The second uses the shock standard deviations estimated by Ireland [2004], namely $\sigma_a = 0.0104; \sigma_u = 0.0035; \sigma_\varepsilon = 0.0033$ for the pre-Volcker period and $\sigma_a = 0.0089; \sigma_u = 0.0002; \sigma_\varepsilon = 0.0028$ for the Volcker-Greenspan period[33]. Results in Table 5 are in line with the previous intuition. Additionally, this last exercise delivers what some authors such as Stock and Watson [2003] have called a 'Great Moderation', i.e. a fall in the volatility of output in the post-1980 sample. However, our model is perhaps too simple for this result to be taken literally.

Table 5 here.

Finally, note that cost push-shocks lead to higher inflation (and inflation volatility) under more limited market participation, even if we assume that policy in the pre-Volcker sample was optimal. As we have noted before, inflation under optimal policy is given by (3.6) and is increasing in λ. It follows immediately that the standard deviation of inflation under optimal policy is $\sigma_\pi = (1+\varphi)\psi / \left[(1-\lambda)\kappa^2\varepsilon + \psi(1-\beta\rho_u)\right]\sigma_u$, which is also increasing in λ.

4.2. Technology shocks. One other dimension along which our model fares well is the effects of technology shocks as documented by Galí, Lopez-Salido and Valles [2003a] . These authors find that in the pre-Volcker era, a positive shock to technology growth (identified as having permanent effects using the method of Galí [1999]) was associated with a fall in output below potential and a fall in inflation. We find it worth re-emphasizing that such empirical responses cannot be compared with their theoretical counterpart in the standard models; there, effects of fundamental shocks cannot be assessed when the policy rule is passive since equilibrium is indeterminate. But this is possible in our framework. Figure 6 plots the responses of the economy under the pre-Volcker parameterization, compared to the benchmark case of optimal policy whereby the central bank tracks the Wicksellian rate. Following Galí [1999] and GLV [2003a] we assume that technology growth ($\Delta a_t \equiv a_t - a_{t-1}$) is given by an AR(1) process $\Delta a_t = \rho^a \Delta a_{t-1} + \varepsilon_t^a$, which implies that shocks to technology have permanent effects. We parameterize the persistence of technology growth for the pre-Volcker sample as in GLV [2003a], namely $\rho_a = 0.7$.

Figure 6 here.

[33] Ireland estimates a model which is different from ours, most importantly (but not only) because in his model $\lambda = 0$. The shock processes' parameters are model dependent, and using them in our model may not be the best route. However, note that this is standard practice in parameterizing general equilibrium models: when one chooses a value for the intertemporal elasticity of substitution, say, one does not estimate it, but rather refers to 'microeconomic studies' estimating it via very different methods.

The model fits qualitatively the empirical findings mentioned above: both inflation and the output gap decrease. The central bank responds to inflation (and deflation) without internalizing the effect on the natural interest rate. The nominal rate declines since there is deflation (and recession), but this response is suboptimal. Note that the response is not suboptimal because it is too weak in the sense that the nominal rate does not decrease enough to make real rates decline! Indeed, that would lead to indeterminacy of equilibrium, which is at the heart of our Inverted Taylor Principle. Instead, the response is suboptimal because it has the wrong sign! The optimal response (plotted in the circle lines) requires nominal rate increases to accommodate the increase in Wicksellian rate brought about by the positive technology shock.

Finally, note that a negative technology shock (a productivity slowdown) in our model generates the opposite responses to those pictured in Figure 6: notably, inflation occurs and the output gap increases. Although both actual and potential output decrease, the former decreases by less than the latter. Comparing these responses to those generated by a cost-push shock (Figure 5) the following remarks are in order. Insofar as one believes recessions in the 1970s to have been associated with a negative potential output, but a positive output gap, one needs to resort to negative technology shocks to explain fluctuations in our model. If one instead regards the 1970s recessions as having meant a fall in the output gap along with inflation, one needs to argue that cost-push shocks played a larger role driving fluctuations. Our model obviously allows for both shocks to have coexisted, but cannot take a stand as to their relative importance in explaining macroeconomic fluctuations. Such an exercise requires estimation of the whole DSGE model incorporating both shocks, and an assessment of their relative importance by calculating variance decompositions. Performing such an exercise (in a DSGE model estimated by maximum likelihood), Ireland [2004] finds that cost-push shocks played much larger role relative to technology shocks in explaining macroeconomic variability in the pre-Volcker era.

4.3. Systematic policy errors. We now briefly investigate the effects of 'honest' policy errors of a particular type, related to an argument already put forward in a series of papers e.g. by Orphanides [2002]. These papers use real-time data on the output gap to estimate policy rules, and argue that the Fed was overestimating the natural rate of output. In this framework, real rates in the pre-Volcker period were too low not because the response to inflation was not strong enough (indeed, they find the policy rule to have been 'active'), but because the Fed was implicitly underestimating the output gap, which it seeked to stabilize. This idea can be accommodated in our model, even without deviating from optimal policy (which is an extreme version of Orphanides' argument that policy was 'good' in the pre-Volcker sample). To see a simple instance of this, consider that the Fed was following what it thought to be optimal policy but it was overestimating the natural interest rate (and the natural output), for instance by overestimating technology growth systematically over that period[34]. Hence, it was systematically moving the interest rate by changing the intercept in the policy rule ε_t more than required, e.g. $\varepsilon_t = \hat{r}_t^* = 1.1 r_t^*$ (where a hat means the estimate of the central bank).

[34] For simplicity, and just to make the point, we assume here that the Fed does not actually learn the true process for the natural rate, neither that it is extracting a signal from a noisy variable. This could be easily accommodated - see Sargent [2002] and references therein.

This case is plotted in Figure 7 in the graphs with triangles (along with optimal policy without estimation errors $\varepsilon_t = r_t^{*}$, graphs with circles) .

Figure 7 here.

Overestimation of the natural interest rate creates in‡ation, and higher volatility of in‡ation compared to the optimal rule, but the mechanism is quite di¤erent from the one emphasized by Orphanides; indeed, real rates here increase too much when compared to optimal policy, which leads to in‡ation since aggregate demand increases by the mechanism stressed throughout this paper when asset markets participation is limited enough. However, by the same mechanism, this would also generate a positive output (gap). Moreover, for signi…cant departures from optimal policy to obtain, estimation errors should be quite large. One could conclude that cost-push shocks might have played an important role in the pre-Volcker era ‡uctuations, since they seem to be the only source of uncertainty that can generate in‡ation and a fall in the output gap at the same time.

The results presented above rely upon a very simple model; we …nd it worth stressing, however, that they are robust to further complications, and only depend on whether the economy was ever marked by limited enough asset markets participation. But insofar as this was the case, business cycle ‡uctuations might have well not changed during the 80's because of 'better' policy. While monetary policy did change with the coming to o¢ ce of Paul Volcker, this might have not been the cause of the business cycle change (this is argued forcefully by Stock and Watson [2002], [2003]). What might have changed are structural features such as the ones emphasized here, leading to more widespread asset markets participation and hence better consumption smoothing. Information on institutional changes supports this view, for the years around 1980 were a period of unprecedented …nancial innovation and deregulation. Policy, instead, might have been quite well managed even before Volcker, and might have changed thereafter precisely because of this structural change; for if …nancial frictions of the type emphasized here were predominant, responding more actively to in‡ation would have led to great aggregate instability. Greater relative variability in macroeconomic aggregates in the 1970's might come precisely from this structural change, let alone the most likely change in the distribution of shocks emphasized i.a. by Sargent [2002].

5. Conclusions

The U.S. economy in the 1965-1980 period was characterized by a high degree of …nancial regulation and limited asset markets participation; this changed in the early 1980s, due to both deregulation and …nancial innovation. We reviewed institutional evidence supporting this statement and outlined a dynamic general equilibrium model incorporating limited participation in asset markets. The model predicts a change in the sign of slope of the IS curve following an exogenous structural change in asset market participation from low to high. We provided new evidence (based on GMM estimation of an aggregate Euler equation) that the sensitivity of aggregate demand to real interest rates changed sign from positive during the pre-Volcker period to negative (as predicted by standard theory) thereafter, consistently with institutional evidence. We showed that under such conditions (labeled 'non-Keynesian') a passive policy rule is required by (i) equilibrium determinacy (ruling out non-fundamental ‡uctuations) and (ii) optimal policy in the sense of maximizing welfare (minimizing output and in‡ation variability). Furthermore, we argued that a central bank behaving in a welfare-maximizing manner would have switched from a passive to an active policy rule endogenously in response to a change in asset market participation. Based on the foregoing results, we suggested that pre-Volcker Fed policy was better than usually thought. Finally, we argued that due to these structural conditions, a Great In‡ation could have resulted in the pre-Volcker period despite well managed policy due to fundamental shocks exclusively.

Since our framework implies that the equilibrium in the pre-Volcker period was determinate, we were able to study the e¤ects of fundamental shocks (which is a notoriously impossible task when equilibrium is indeterminate as for example in Clarida, Galí and Gertler [2000] or Lubik and Schorfheide [2004]). We found that theoretical responses to fundamental shocks conform stylized facts and empirically estimated responses. Notably, we found that cost-push shocks (argued by many others to have been the primary source of ‡uctuations in that period) generate considerably higher in‡ation and in‡ation variability in the pre-Volcker period than they do in the Volcker-Greenspan period for reasonable parameterizations. We also found that the theoretical responses to technology shocks in the pre-Volcker economy match empirical responses (estimated by others such as Galí, Lopez-Salido and Valles [2003a]), leading to de‡ation and output below potential. In‡ation in response to technology shocks could have resulted in the pre-Volcker sample if the central bank overestimated the natural rate of interest (or technology growth), despite following an otherwise optimal policy. This conforms the view of some authors (e.g. Orphanides [2002]) about pre-Volcker Fed policy, but would also imply a positive output gap response, something not observed in the data. All in all, our results may contribute towards an explanation of the change in business cycles based on a change on the structure of the economy (in this case, developing …nancial markets and hence better consumption smoothing), rather than 'better policy'. Stock and Watson [2002], [2003] provide empirical evidence supporting this view. The change in policy, instead, might represent an 'optimal' response to the deregulation of …nancial markets; for optimality would have indeed required switching from passive to active policy if output and in‡ation variability and equilibrium uniqueness were of any concern.

The framework of this paper has been simpli…ed for the sake of clarity in making the point that limited asset markets participation may help solving the 'Great In‡ation' puzzle. There are two main directions in which we seek to extend our analysis. From a theoretical viewpoint, assuming an exogenous share of assetholders is only justi…able on tractability grounds. The degree of asset markets participation is likely to vary over the cycle in an endogenous manner. Introducing this features would allow for studying a smoother transition in the degree of asset market participation (rather than the sharp, exogenously induced change analyzed here); it would also likely modify the welfare analysis. From an empirical viewpoint, recently developed methods along the lines of Lubik and Schorfheide [2004] allow the estimation of the entire dynamic general equilibrium model and the assessment of its determinacy properties using Bayesian techniques. Recent work (Bilbiie and Straub [2004]) applies these techniques to the model used in this paper.

The explanation proposed here abstracts from a few aspects emphasized by others: in‡ation bias; changing variance of shocks; information imperfections (introduced only in a crude way to show consistency with 'natural rate misperceptions' stories) and learning. This is not to say that we believe such aspects have nothing to contribute towards explaining the Great In‡ation. We merely argue that our explanation captures some features that other theories by themselves do not. In that sense, it could be part of the explanation, together with other, complementary and consistent theories. What weighting should it receive in solving the puzzle is of course an open issue.

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GMM estimates, pre-Volcker					
potential output	b	SE(b)	d	SE(d)	J-test p-val[35]
HP (m = 0)	0.85	0.11	0.30	0.10	0.59
HP (m = -1)	1.15	0.09	0.18	0.09	0.71
Quadratic	0.97	0.06	0.33	0.12	0.67
Segmented	1.02	0.07	0.25	0.13	0.65
ST2	1.03	0.05	0.28	0.10	0.82
ST952	1.02	0.05	0.28	0.11	0.81
CBO	1.03	0.05	0.33	0.12	0.74
BP2	1.02	0.05	0.16	0.04	0.55
HP, exog. instr.	0.94	0.08	0.16	0.05	0.86
Quadratic, exog. instr.	0.99	0.04	0.35	0.06	0.97
CBO, exog. instr.	1.04	0.03	0.32	0.06	0.97
ST, exog. instr.	0.99	0.05	0.33	0.06	0.96
ST952, exog. instr.	1.15	0.09	0.17	0.09	0.71
GMM estimates, Volcker-Greenspan					
HP, (m = 0)	1.43	0.10	-0.13	0.04	0.62
HP (m = -1)	1.36	0.09	-0.11	0.04	0.50
Quadratic	0.94	0.03	0.01	0.04	0.34
Segmented	1.07	0.05	-0.09	0.06	0.32
ST2	1.22	0.03	-0.20	0.03	0.65
ST952	1.26	0.03	-0.15	0.03	0.67
CBO	1.18	0.03	-0.08	0.04	0.47
BP2	1.10	0.04	-0.02	0.02	0.25
HP, exog. instr.	0.57	0.09	0.06	0.07	0.85
ST, exog. instr.	1.04	0.04	-0.14	0.04	0.69
ST952, exog. instr.	1.05	0.06	-0.12	0.04	0.72

Table 1. GMM estimation of the theoretical IS curve for two sub-samples.

Pre-Volcker						
interest rate	$a_1 + a_2$	b	SE(b)	d	SE(d)	J-test p-val.
$k = 4, m = 0$	0.53	0.35	0.10	0.10	0.06	0.446
$k = 4, m = -1$	0.46	0.32	0.11	0.23	0.07	0.489
$k = 1, m = 0$	0.13	0.89	0.14	0.16	0.17	0.572
$k = 1, m = -1$	0.58	0.46	0.08	-0.04	0.083	0.476
Volcker-Greenspan						
$k = 4, m = 0$	0.54	0.53	0.08	-0.015	0.01	0.158
$k = 4, m = -1$	0.53	0.52	0.07	-0.014	0.01	0.164
$k = 1, m = 0$	0.5	0.65	0.10	-0.05	0.01	0.161
$k = 1, m = -1$	0.46	0.69	0.11	-0.05	0.01	0.152

Table 2. GMM estimation of the augmented IS curve for two sub-samples.

Table 3. Conditional standard deviations, cost-push shock

	Pre-Volcker	Volcker-Greenspan
σ_x	0.838 98	1
$\sigma\pi$	4.776 2	1
σ_r	2.547 3	1

Table 4. Conditional standard deviations, cost-push shock

	Pre-Volcker		Volcker-Greenspan	
$\varphi = 5$, threshold $\overset{1}{\bar{\lambda}} = 0.19$				
	$\lambda = 0.25$	$\lambda = 0.5$	$\lambda = 0.05$	$\lambda = 0.18$
σ_x	1.53	3.61	4.96	5.11
$\sigma\pi$	4.00	6.35	0.86	0.234
σ_r	1.91	4.574	1.162	0.316
$\varphi = 3$, threshold $\overset{1}{\bar{\lambda}} = 0.28$				
	$\lambda = 0.3$	$\lambda = 0.5$	$\lambda = 0.05$	$\lambda = 0.25$
σ_x	7.30	5.86	7.13	7.72
$\sigma\pi$	2.38	4.88	1.37	2.25
σ_r	1.69	3.51	1.85	3.14

Table 5. Unconditional standard deviations (technology, cost-push and policy shocks)

	Pre-Volcker	Volcker-Greenspan
Unit standard deviations		
σ_x	4.20	5.124
$\sigma\pi$	4.118	1.031
σ_r	3.124	1.533
Estimated standard deviations		
σ_x	0.248	0.183
$\sigma\pi$	0.243	0.075
σ_r	0.184	0.045

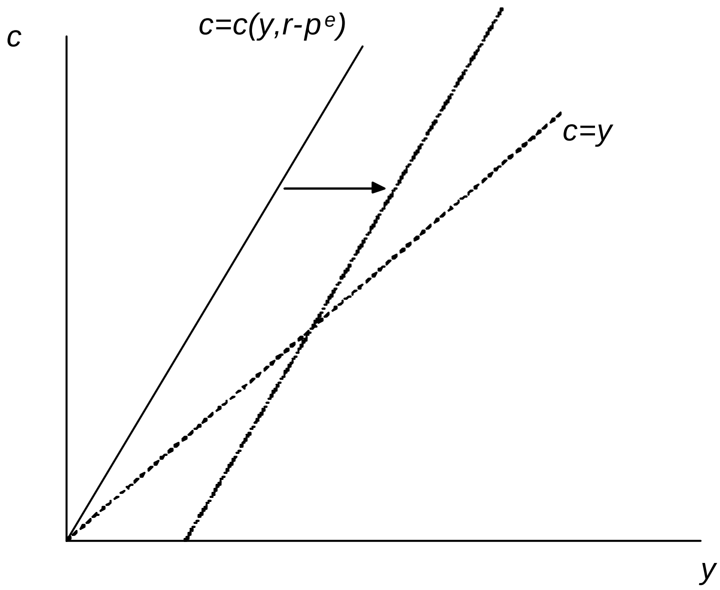

Figure 1. The Non-Keynesian Crosss

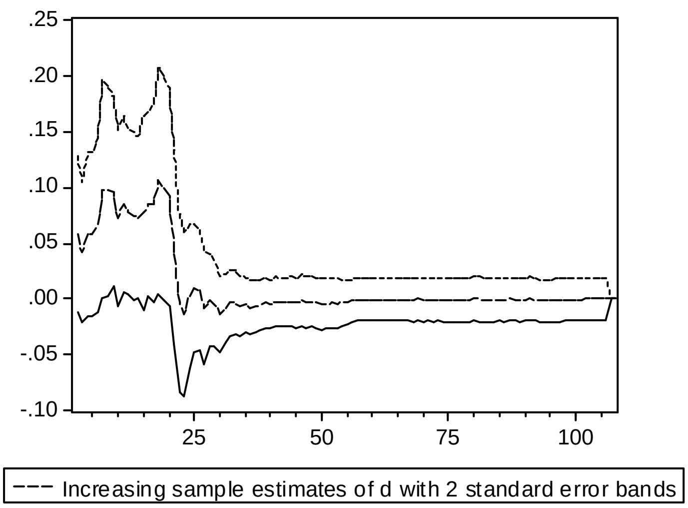

Figure 2.

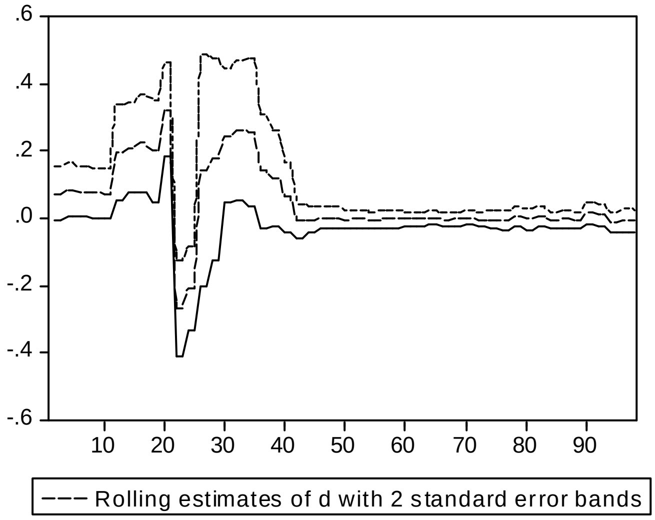

Figure 3.

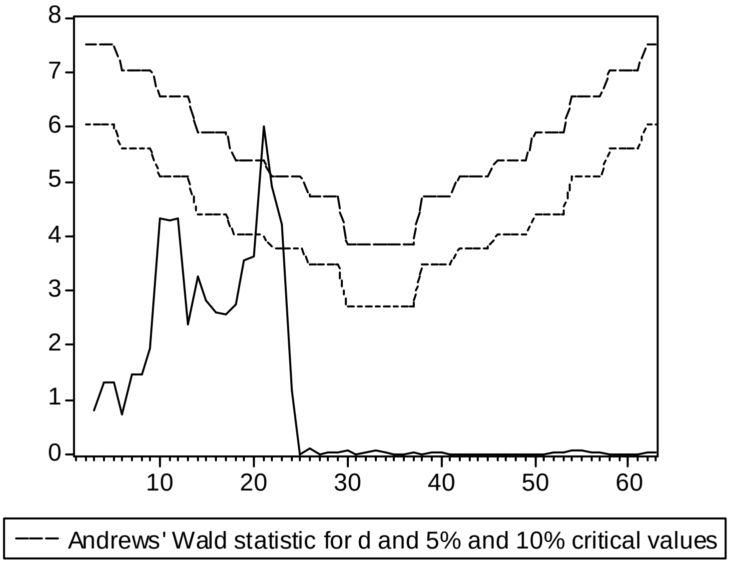

Figure 4.

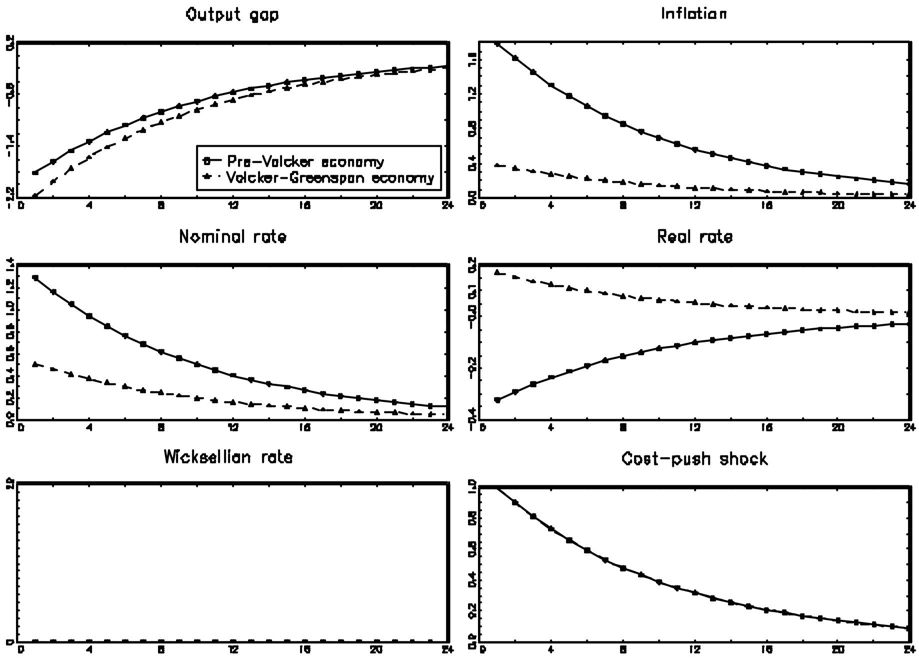

Figure 5. Impulse responses to unit cost push-shock. Line with circles has $\lambda = 0.4$ and $\phi_\pi = 0.8$; line with triangles has $\lambda = 0.05$ and $\phi_\pi = 1.5$. Otherwise baseline parameterization.

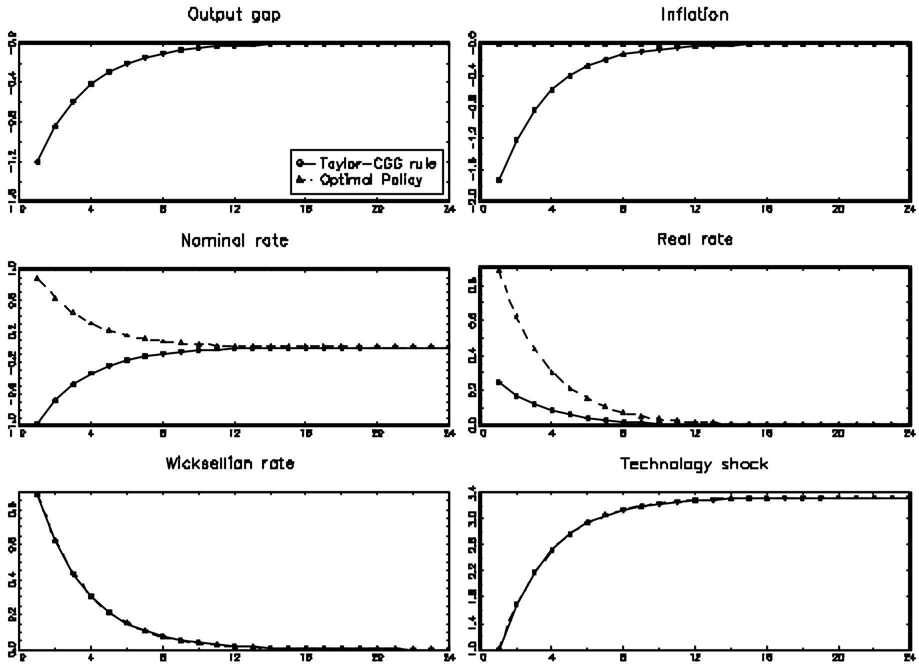

Figure 6. Impulse responses to unit shock to technology growth. Estimated rule is with circles, optimal policy with triangles.

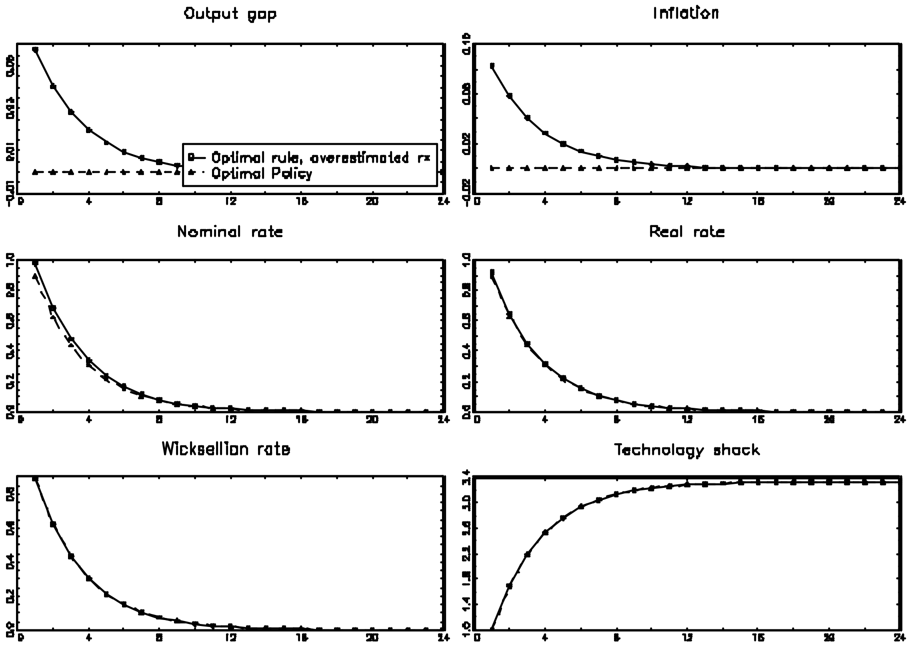

Figure 7. Impulse responses to unit technology growth shock. In the 'circles' economy, natural rate of interest is systematically overestimated.